

Marijuana Legalization and College Student Use: Early Evidence

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Abstract: This paper examines the effects of recent legalization of recreational marijuana on use of marijuana by college undergraduates. Using multiple years of survey data from the National College Health Assessment, we show that students at Washington State University experienced a large increase in the likelihood of and frequency of marijuana use after legalization. The effect is strongest for females, Black students, and Hispanic students. Additionally, we find that the response for underage students is at least as large as the response for legal-age students. No consistent, significant change in the consumption of alcohol, tobacco, and other drug use after marijuana legalization was found.

Keywords: Marijuana, Cannabis, Marijuana Legalization, Substance Use, College Students

Abbreviations: GPA: Grade point average; NCHA: National College Health Assessment; WSU: Washington State University

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1. Introduction

After years of debate about marijuana legalization, recreational marijuana was legalized for adults 21 years of age or older in several states beginning with Colorado and Washington in 2012. In 2014, Alaska, Oregon, and the District of Columbia voted to legalize recreational marijuana with laws similar to those in Washington and Colorado. Most recently, California, Massachusetts, Nevada, and Maine all passed ballot measures legalizing recreational marijuana in November 2016. Due to their recent passage, many impacts of these measures are yet to be determined. As Washington and Colorado were the first states to legalize marijuana for recreational use, however, sufficient data to evaluate outcomes since legalization are now becoming available for these states. We use the available data for students at Washington State University (WSU) to present here an early exploration of the role legalization plays in marijuana use among college students, a population generally thought to be predisposed towards risky behavior, including experimenting with marijuana and other drugs. Our main hypothesis is that legalization of recreational marijuana induces more students to use marijuana by lowering one or more of the costs of using it. These costs may include the threat of punishment, the price and/or availability of marijuana, a lack of social acceptability, and an inherent desire to be law-abiding.

Legalization of marijuana in some U.S. states can be observed in three stages: decriminalization, medical-use legalization, and full recreational legalization. In the early 1970s, eleven states officially decriminalized the possession of small amounts of marijuana.¹ Though there is some evidence that use may increase with decriminalization (e.g., Damrongplasit et al., 2010), the majority of research finds no evidence for such an increase (Thies and Register, 1993; Reinerman et al., 2004). To explain why decriminalization seemingly has no effect on marijuana use, MacCoun et al. (2009) suggest that complexity of drug laws, including the inconsistency between federal and state drug laws, mean that people may not really know the legal risks of marijuana use or possession.

Since 1996, 28 states have legalized medical marijuana, which is the use of marijuana solely for the use of treating disease or symptoms and not for recreation. These changes offer some ideas on how recreational legalization might affect use. There is evidence that such laws have not increased marijuana use among people younger than 21 (Khatapoush and Hallfors, 2004; Lynne-Landsman et al., 2013; Choo et al., 2014; Anderson et al., 2015). If attention is not restricted to youth, however, the research suggests that medical marijuana laws are associated with more non-medical use (Cerda et al., 2012; Wen et al., 2014), more marijuana-related arrests and marijuana rehabilitation treatments (Chu, 2014), an increase the supply of marijuana (Anderson and Rees, 2014), and a decrease in the price of illegal

¹ Decriminalization is the elimination of criminal punishments such as arrests and jail time associated with the possession of small amounts of marijuana, presumably intended for personal use rather than for sale or distribution. Decriminalization is implemented differently in various states, particularly with respect to whether other punishments such as fines are still in force and whether repeat offenders are criminally prosecuted.

marijuana (Malivert and Hall, 2013). Pacula et al. (2015) add that like decriminalization laws, not all medical-marijuana legalizations are created equal. In particular, they find that legal protections for marijuana dispensaries are associated with even higher levels of use and abuse both by adults and by those under the age of 21.

No literature has yet assessed the impact of full legalization on marijuana use, though Pacula (2010) provides a full review of the economic literature related to marijuana consumption more generally and predicts (based on the current research) that use will increase due both to new users and to an increase in the use of current users. Anderson et al. (2013) find evidence that full legalization has decreased the price of marijuana, which could also lead to an increase in consumption. Pacula and Lundberg (2014) emphasize the eventual policy importance of both measuring changes in the intensity of use versus only measuring prevalence of use (since heavy users are likely to have a large effect on total consumption) and measuring the elasticity of use for different groups.

Our population of interest in this paper is students at WSU in Pullman, Washington. Many changes with respect to marijuana law and availability have occurred in Washington in the past two decades. In 1998, Washington state residents voted to decriminalize marijuana for medical use by qualifying adults. In 2007, 2010, and 2011, the 1998 law was amended to expand qualifying conditions for medical use of marijuana. Then on November 6, 2012, Washington Initiative 502 was passed. Legal possession and use of marijuana took effect in December 2012 and the first licensed retail stores opened their doors in July 2014. Although marijuana use has increased in the state of Washington since 1998 (potentially due in part to the legalization and expansion of medical marijuana laws over this time period), in this paper, we investigate whether the 2012 legalization of recreational marijuana increased use above the long-term trend toward more use in Washington.

Marijuana legalization might increase its use because both the direct and social costs of using may fall. From basic economic theory, we expect that marijuana is a normal good with a downward-sloping demand curve and that use will rise as the price falls. Though Caulkins and Pacula (2006) find that most marijuana users obtain their marijuana for free from friends or family and Gallet (2014) estimates that the demand for marijuana is much less responsive to price changes than other illegal drugs, van Ours and Williams (2007) find that lower prices are associated with more new users and a longer duration of use. Davis et al. (2015) estimate a price elasticity of demand for marijuana of between -0.67 and -0.79. Legalization clearly increases the availability of marijuana for those 21 and older, and likely for those under 21 as well. Based on predictions that legalization will lower the price of marijuana and evidence that it has (e.g., Anderson et al, 2013), we hypothesize that legalization will increase the likelihood that a student will choose to use marijuana.

According to deterrence theory, a person is more likely to participate in an activity if the threat of punishment associated with that activity decreases. It is not clear at this point what effect legalization has on the threat of punishment to underage users of marijuana, but legalization eliminates the threat of punishment (at least at the state level) to legal-age potential users. For this reason, we hypothesize that legalization will increase the

likelihood that legal-age students will use marijuana and have an uncertain effect on underage students.

Another factor is Deviance Regulation Theory (Blanton and Christie, 2003), which predicts that behavior will change if perceived norms change. Until recently, the legal norm in Washington to not use marijuana recreationally provided a bias against marijuana use. Although medical marijuana legalization likely changed the social acceptability of marijuana use, full legalization sends a stronger message about changing norms, which could lead some students to increase consumption.

The first indication that marijuana use may have changed in Washington after the vote for legalization is observed in the trend of reported marijuana use. Figure 1 shows the proportion of students who reported using marijuana in the past 30 days across time periods. For comparison, we also include the proportions over time of students who reported using alcohol, tobacco, and illegal drugs other than marijuana. Because we are mostly interested in what happens after the legalization vote at the end of 2012, proportions for use of each substance are presented as deviations from the 2012-use levels. We observe a large increase over a general upward trend in marijuana users after 2012. Use of the other substances does not show a similar increase. This initially suggests that something unique may have occurred to marijuana use when marijuana was legalized.

More rigorously, we test for changes in the reported use of marijuana at two points: after the vote in 2012 and after legal sales began in Pullman in 2014. We find strong evidence that the probability of having used marijuana in the past 30 days increased both in 2014 (after the vote but before legal sales), and again in 2015 after the first marijuana stores had opened.

We also test for these same changes within specific subgroups of the population. Most importantly, we test whether the change in use is different for legal-age students and those under 21, because only those over 21 are directly affected by legalization. We find that for those under 21, the probability of using marijuana increased both after the vote and after legalization took effect, but for students age 21 and over we find no significant increase at either juncture. Among other subgroups, we find consistent evidence of an especially large increase in the probability of use for females and for Black and Hispanic students (pooling both genders).

Because marijuana could be a substitute or complement of other drugs, or the vote could signal a change in social norms, we then check if the use of tobacco, alcohol or illegal drugs other than marijuana changed at the same time that marijuana legalization occurred. We find no statistical support that the changes in marijuana legalization affected the probability of use for any of these substances.

In addition to likelihood of marijuana use, we are also interested in the intensity of marijuana use. Hence our final test is whether the average frequency of marijuana use increased after legalization or legal sales. The results show the intensity of marijuana increased with the vote for legalization, but this effect fell off after legal sale commenced.

2. Data

In order to conduct the analyses in this paper, we use repeated cross-sectional data from the National College Health Assessment (NCHA), which is a comprehensive health survey collected and made available by the American College Health Association. In particular, we use the collection of surveys administered to repeated cross-sections of undergraduate students at Washington State University (WSU) in Pullman, Washington.² WSU has participated in the NCHA in seven different survey years: 2005, 2006, 2008, 2010, 2012, 2014, and 2015. The total number of observations in the sample is 14,485, with a mean of 2,069 students surveyed each year. Table 1 shows the actual number of students who participated each year. Due to missing values in one or more of the variables of interest, our actual estimation sample contains 13,335 observations. The distribution of surveys across years for the excluded observations is nearly identical to the distribution for the whole sample.

In addition to other important health factors, the NCHA surveys contain questions about students' use of alcohol, tobacco, and other drugs including explicit questions about marijuana use. Our main variable of interest is a count of how many times a student used marijuana in the past 30 days. For tests 1 and 2, this variable is modified into a binary indicator of whether a student used marijuana at all in the past 30 days. Variables included as controls in our regression specifications include measures for age, sex, race, and year in school. In other specifications, we also include respondents' grade point average (GPA), type of residence (including whether on- or off-campus), membership in a fraternity or sorority, and indicators for whether a student is international and whether they have used tobacco, alcohol, or any illegal drugs (other than marijuana) in the past 30 days. Table 2 provides summary statistics on these variables for the 13,335 observations included in the regressions.³ Also included in this table are mean values for all variables both before and after legalization.

According to the Integrated Postsecondary Education Data System (IPEDS), the undergraduate students enrolled at WSU in fall 2014 were 49 percent male, 65 percent

² The NCHA was also administered to graduate students, but they are excluded from our analysis in order to focus on the impact on undergraduate students.

³ The full sample contains 14,485 observations but some of these observations are excluded from analysis due to missing values on one or more variables. With the exception of tobacco use, no significant difference for these variables was found between the observations that were included and those that were excluded from analysis. For tobacco use, the excluded observations had a mean of 0.27 and standard deviation of 0.44 compared to the included observations that have a mean of 0.19 and standard deviation of 0.39. We have no reason to believe that the estimates of our main results should be affected by this difference. We also observed no significant difference between the changes in marijuana use over time for observations included in the analysis and for those excluded.

White, 3 percent Black, 12 percent Hispanic, and 5 percent Asian (Institute of Education Sciences, 2011). WSU reports that in 2014 the average age across all six campuses (including online students) was 23 for undergraduate students (Washington State University, 2015).⁴ According to the Center for Fraternity and Sorority Life at WSU, between 2013 and 2015, 21-24 percent of undergraduate students were in fraternities or sororities and the average GPA of all WSU students was 2.92 (WSU Center for Fraternity and Sorority Life, 2015).

Compared to these statistics, the NCHA sample at first appears to be underrepresented by males, Hispanic students, and students in fraternities or sororities. By the same token, the sample may contain an oversampling of White students, Asian students, young students, and students with higher GPAs. Some of these differences might be explained in part by the fact that the NCHA sample contains data from as far back as 2005. If we examine the summary statistics for these variables with respect to data only from 2014 and 2015, we see that 11 percent of students are Hispanic and 21 percent are in fraternities or sororities (see Table 2), which more closely matches the data from IPEDS and WSU reports. Additionally, in the NCHA surveys, students were encouraged to select all races that apply to them rather than choose the race with which they identify most. This may help explain the apparent oversampling of Whites and Asians.⁵ GPA is likely to be slightly biased upward in the NCHA sample due to the fact that it is both rounded to the nearest whole point and self-reported by the students. Finally, the average age of students in the NCHA sample is likely lower in part because it only includes students from the Pullman campus, which is WSU's main undergraduate campus. The average age reported by WSU includes students from all campuses including online students who are more likely to be older.

3. Estimation Methodology

We use a logit regression to estimate the probability of a student choosing to engage in use of a substance (whether use of marijuana or another substance). When testing the intensity of marijuana use, we employ an ordinary least squares (OLS) regression to estimate the number of days that a student chooses to use marijuana. Specifically, we estimate the following equation using a logit regression⁶:

$$m_i = \begin{cases} 1 & \text{if } \mathbf{X}_i\mathbf{B} + \gamma_1\text{Year}_i + \gamma_2\text{Legal}_i + \gamma_3\text{Sales}_i + \varepsilon_i > 0 \\ 0 & \text{otherwise} \end{cases}, \quad (1)$$

where m_i is an indicator of whether individual i has used marijuana and $\varepsilon_i \sim \text{logistic}(0,1)$. Intensity of use is estimated with OLS regression:

⁴ WSU has extension campuses in Spokane, Tri-Cities, Vancouver and Everett, WA.

⁵ Whites and Asians are the most highly correlated race groups in the sample.

⁶ The results of this regression are robust to estimation with probit or OLS regression as well.

$$\text{Number of Days}_i = \mathbf{X}_i\boldsymbol{\Gamma} + \delta_1\text{Year}_i + \delta_2\text{Legal}_i + \delta_3\text{Sales}_i + \eta_i, \quad (2)$$

where the left-hand side is the number of days that individual i chose to use marijuana. On the right-hand side of both equations, \mathbf{X}_i is a vector of individual-level characteristics, Year_i refers to the year that individual i completed the survey (this estimates a linear trend in the dependent variable over time), Legal_i is an indicator of whether the student was surveyed in 2014 (the first survey that occurs after legalization), and Sales_i is an indicator of whether the student was surveyed in 2015 (after legal sales became available).⁷ The timing variables in this estimation model (including Year_i , Legal_i , and Sales_i) are variables that control for changes in marijuana use that occur between survey periods. This means that changes over time in price, punishment, social norms, etc. are all captured by these variables.

When exploring the probability of marijuana use, we run each regression four times, each time including more variables in \mathbf{X}_i , starting with the least likely to be endogenously correlated with legalization. The first regression contains no variables in \mathbf{X}_i ; the second regression adds an indicator variable for each year of age between 19 and 24 and for any age over 24, and indicators for sex, race, and year in school; the third regression adds indicators for GPA, for whether a student is international, for whether a student is in a fraternity or sorority, and for the student's type of residence; the fourth regression adds separate indicators for whether a student has used in the past 30 days tobacco, alcohol, or illegal drugs other than marijuana.

Our test on the probability of use for marijuana and other substances is whether γ_2 , γ_3 , and $\gamma_3 - \gamma_2$ are statistically different from zero using a standard t-test after running the logit regression on the full sample. Coefficient γ_2 represents the deviation from a linear trend (because we are independently controlling for Year_i) in the likelihood of having used marijuana associated with a student who was surveyed in 2014 (the first year after legalization). The coefficient γ_3 is the same deviation associated with a student who was surveyed in 2015. Every student surveyed in 2015 was subject to both the legalization and the legal sales treatments. Thus, for these students the actual estimate of the isolated legal sales effect is the difference $\gamma_3 - \gamma_2$. Data limitations prevent us from establishing a reliable control group, so we have what amounts to an “event” study.⁸ Hence we cannot conclude

⁷ Initiative 502 was passed by popular vote in November of 2012 and possession of marijuana became legal for adults in December of 2012. All 2012 surveys were administered in the spring, before legalization, and all surveys in 2014 and 2015 occurred after possession was legal. Likewise, legal sales of marijuana began in the state of Washington in July 2014 and in the city of Pullman (where WSU is located) in October 2014. The 2014 surveys were administered in the spring, before legal sales began, and all 2015 surveys were completed after legal sales began.

⁸ Although the NCHA has been administered to a sample of students at colleges and universities across the nation since 2000, we were unable to obtain data from any other university. Although we do have access to the pooled national dataset, this dataset does not contain school or state identifiers. Without these identifiers, it is impossible to determine whether any particular student is

definitively that the changes we observe in the probability of marijuana use are due to legalization or some other external factors. Nevertheless, we are able to test the hypothesis that different subgroups of students responded differently after legalization, with a special interest in comparing underage students to those over the legal consumption age of 21.

Analogously, when testing if the rate of use has increased with equation 2, we use standard t-tests to determine whether δ_2 , δ_3 , and $\delta_3 - \delta_2$ are statistically different from zero. Similar to the results of the logit regressions, δ_2 represents the deviation from a linear trend in the average number of days that a student used marijuana for students surveyed in 2014 (the legalization effect). The coefficient δ_3 is the same deviation associated with a student who was surveyed in 2015, and $\delta_3 - \delta_2$ is the estimate of the isolated legal sales effect.

4. Results and Discussion

4.1 Full-sample Likelihood of Marijuana Use

The estimates from the first set of logit regressions on the probability of having used marijuana in the past 30 days are reported in Table 3. The far left column in this table shows the basic regression, controlling only for a linear trend. Column 2 shows the results of the regression with demographic controls added including age, sex, race, and year in school. Columns 3 and 4 show the results with more covariates added, some potentially endogenous.

Controlling for a predicted increase of about 1.2 percentage points each year over this time, we find evidence that marijuana use among WSU students increased after the legalization vote, and that this increase was maintained at least through the next two years.⁹ The main coefficients of interest are those for Year 2014 (After Vote) and Year 2015 (After Legal Sales), which are the increases in reported marijuana use above the predicted trend after marijuana was legalized by vote in November 2012 and after legal sales began in July 2014, respectively. We find a positive change in marijuana use between 2.0 and 3.5 percentage points after legalization across the four specifications. Each estimate is statistically different from zero with at least 95-percent confidence. This implies that the vote to legalize recreational marijuana at the end of 2012 was associated with a 12-22 percent

treated with legalization or not. Additionally, the timing of surveys in the national dataset is different from the surveys available from WSU and the sample of schools changes sporadically from year to year, thus preventing even a comparison study using the national data.

⁹ Some may note the main increase in marijuana users appears to begin after 2008. To verify that our results are particular to changes that occur in the 2014 and 2015 samples, we run the same analysis described in this paper several times using each other year as the assumed treatment year. In each such regression, every year after the assumed treatment year is considered “treated”. No other pseudo-treatment is associated with a significant increase in marijuana users over the estimated linear trend.

increase in the probability that a random student had used marijuana.¹⁰ This result is robust to including controls for age, sex, race, year in school, international status, GPA, membership in the Greek community, type of residence, and other drug use (including tobacco, alcohol, and illegal drugs).

The estimates for the effect of Year 2015 are also positive and statistically significant, which suggests that the effect of legalization continued into 2015. The additional effect of legal sales is the difference between these two estimates, which is consistently positive but not statistically different from zero at conventional levels; t-scores for these differences range from 0.43 ($p=0.67$) to 0.88 ($p=0.38$) across the four specifications. We find no strong evidence here that legal sales had any additional impact above the linear trend on the overall proportion of marijuana users.

This regression model also provides several *ceteris paribus* estimates of relative marijuana use among WSU students. In particular, male students are between 2 and 7 percentage points more likely to have used marijuana than females. Black and White students appear to be the most likely to use marijuana compared to other races. Asian students are the least likely racial group to use marijuana. In results not shown (but available upon request), we also see a generally decreasing likelihood of marijuana use with age. Students age 18-20 are the most likely to have used marijuana; from ages 21-23, we see between a 2 and 9 percentage point decrease in likelihood; at age 24, the likelihood of having used marijuana is estimated to be between 9 and 12 percentage points lower than for 18-year-old students; and students older than 24 are estimated to be between 12 and 15 percentage points less likely to have used marijuana than 18-year-old students. In column 2, we observe no statistically significant difference between students of different years in school, but after controlling for GPA, Greek membership, residence, and international status, it appears that 1st-year undergraduates are the most likely to use marijuana by between 3 and 5 percentage points over students of other years. International students are between 4 and 7 percentage points less likely to use marijuana than domestic students, students with a 4.0 GPA are between 3 and 10 percentage points less likely to use than other students, and students in fraternities or sororities are between 4 and 12 percentage points more likely than other students. With respect to type of residence, we find that living in the university dormitories or living with parents is strongly negatively correlated with marijuana use—this is likely due to the level of monitoring and enforcement that is likely to occur at these locations. The final column contains estimates of the correlations between marijuana use and use of other substances, though we note the high probability of bias in these estimates due to these variables likely being endogenously correlated. Nevertheless, the model predicts that the likelihood of marijuana use is positively correlated with the use of tobacco, alcohol, and illegal drugs.

¹⁰ Percent changes are calculated using the estimated increase in percentage points for 2014 from the regression results, and dividing this by the percentage of students before 2014 who reported having used marijuana; e.g., $0.02 / 0.16 = 0.125$ or 12.5 percent.

4.2 Likelihood of Marijuana Use by Subgroup

To further investigate the character of the observed increase in marijuana usage, we repeat the regressions on likelihood of having used marijuana for different subgroups. These results are presented in Table 4. The results of these regressions are generally consistent across all four specifications for each group. For brevity we report only the results from the specification that includes only controls for age, sex, race, and year in school (equivalent to Column 2 in Table 3). In order to better assess the impact of legalization, the proportion of each group that reported having used marijuana before 2014 is included at the bottom of each column.

Though the estimates differ greatly in magnitude, and only a few of the estimates are statistically significant at conventional levels, all groups are associated with a non-negative trend and a positive increase in marijuana use above that trend after legalization.

The results suggest that legal-age and underage students responded differently to legalization. The estimates for the increase in underage students' likelihood of using marijuana are large and statistically significant with a p -value $< .01$, while the estimates for legal-age students are smaller and not statistically different from zero (using a chi-squared test after estimation, the differences between the two groups' estimates for 2014 and 2015 have p -values of 0.206 and 0.955, respectively). Though not statistically significant, these differences suggest that marijuana use by underage students is affected at least as much as that by legal age students. It is also relevant to note that the difference between the estimates for 2015 and 2014 for legal-age students is marginally statistically significant with a p -value = 0.081. This hints that some legal-age students may have waited to use marijuana until after they could obtain it legally from authorized distributors.

The subgroup analysis gives us some insight into which groups are driving the changes in the entire sample. The most remarkable result is the relatively large increase in likelihood of marijuana use for Black and Hispanic Students. Among the different race groups, only Hispanic students showed changes that are statistically significant with a p -value < 0.05 (p -value < 0.01 for 2014). The likelihood of marijuana use among Black and Hispanic students increased in 2014 by 15.8 and 14 percentage points, respectively. Although the estimates for Black students lacked statistical significance, this change represents an 88 percent increase in recent users for Black students and a 93 percent increase in users for Hispanic students, and is 8-9 times the estimated effect for Asian and White students. The relatively large increase for Black and Hispanic students is made more significant by the fact that this increase occurs over a previously non-increasing trend for both groups. In fact, though not statistically different from zero, Black and Hispanic students are the only groups with estimated negative trends over this time. In other words, both groups started out with a proportion of marijuana users that remained essentially constant since 2005 until legalization, after which Black and Hispanic students were among the most likely students to have used marijuana.

Legalization also had a bigger effect on females than males, with the former statistically significant with a p -value < 0.05 , while for males the estimates were not significant at

conventional levels, and the magnitudes of the effect of the vote and legal sales were much smaller. Estimates also indicate that marijuana use by domestic students was more affected than its use by international students, and legalization had more of an effect for non-Greeks than Greeks.

4.3 Likelihood of Use of Other Substances

The results from the logit regressions on the likelihood of using alcohol, tobacco, and other illegal drugs are reported in Table 5. Again for brevity, we report only the results for the regressions that include only controls for age, sex, race, and year in school. For convenience, we report again the estimates for marijuana use from column 2 of Table 3. We find that on average the yearly trends in the likelihood of use for alcohol, tobacco, and illegal drugs are in the opposite direction and significantly smaller in magnitude than the yearly increase of 1.2 percentage points in marijuana use. No significant changes occur in 2014. In 2015, the only significant changes include a 2.4-percentage-point (12 percent) decrease in the likelihood of using tobacco and a 2.2-percentage-point (55 percent) increase in the likelihood of using other illegal drugs. We may expect a change in marijuana usage to affect the use of alcohol in some way, but we do not see any evidence supporting such a change. This provides some evidence that legalization was the cause of the change in marijuana usage rather than some other change that would affect use of all substances; e.g., changes in income.

The estimated increase in the use of other drugs suggests that perhaps legalization of marijuana not only affected norms against marijuana use, but also had a spillover effect on norms against other illegal drugs or that more marijuana use may have led to the use of other drugs. This potential increase may be particularly troubling from a policy standpoint. Nevertheless, it is important to note that with such a small number of people having reported using illegal drugs, it is difficult to determine the reliability of this estimate. Additionally, with respect to the reported changes in both tobacco and other drugs, the change did not occur until 2015, whereas the major change in marijuana use had already occurred at least a year prior. Furthermore, relative to other effects discussed in this paper, the changes presented for tobacco and illegal drugs are not as robust to alternative specifications and estimation methods (results available upon request). More investigation beyond the scope of this paper is needed in order to determine the true nature of this estimated change in the use of other substances.

4.4 Marijuana Use Intensity

The results of the OLS regressions with respect to regularity of marijuana use are presented in Table 6. In 2014, we find an increase in the frequency of marijuana use of between 0.4 and 0.5 days out of the past 30 days above a linear trend of between 0.13 and 0.16 days per year. This represents a 32-40 percent increase over the pre-2014 average number of days. This increase is statistically significant across specifications with at least 95-percent confidence. These results suggest that legalization may have increased the average frequency of marijuana use (either because new users are more likely to use more often or because inframarginal users chose to use more frequently). Interestingly, however,

the estimates for the increase in 2015 over the predicted trend are smaller than the estimates for 2014 and are not statistically significant at conventional levels. Though the magnitude of the estimates in 2015 do not appear to be significantly lower than for 2014, the lack of a significant increase in 2015 could indicate that the increase in frequency is short-lived—perhaps born out of the excitement of legalization—but that the equilibrium trends in frequency are generally unaffected by legalization. Alternatively, if the students who begin using marijuana after legalization and before legal sales are systematically different from the students who wait to use marijuana until after legal sales, as we suspect they are, this result may indicate that a large proportion of students who began using before legal sales of marijuana are more likely to use it more frequently.

5. Conclusions

We provide some of the first evidence of the short-term effect that recreational legalization has on college students' use of marijuana. At Washington State University, legalization of marijuana was associated with a significant increase both in the proportion of undergraduate students who reported having recently used marijuana and in the average frequency of marijuana use. This increase after legalization is robust to multiple specifications and statistical models and varies across subgroups. In particular, we find that underage students, females, Black students, and Hispanic students experienced the most significant impacts of legalization. Notably, we also find that underage students had at least as big of a response as legal-age students. It is likely that factors other than legality directly are driving the increase in use. Changes in price, availability, social acceptability, and perhaps reduced law enforcement are likely to affect students of all ages whereas only legal-age students experience a direct change in the cost of having a desire to be law-abiding. We find evidence that some students may have waited to use until they could legally obtain marijuana from authorized distributors, but many students (including underage students for whom marijuana usage was and continues to remain illegal) increased marijuana usage for other reasons than mere legality. Finally, we find evidence that students did not significantly change their use of alcohol, tobacco, or illegal drugs other than marijuana at the same time that marijuana use changed.

Legalization of recreational marijuana is still very new. To the extent that WSU is like other universities, this paper provides some idea of how students are affected in the first couple of years after legalization, but it is still too early to know what kind of long-term impacts legalization will have on marijuana use. Future studies will benefit from more post-legalization observations in order to determine whether the change in marijuana use is short-lived or if the impact of legalization fades or grows over time. Furthermore, any implications are limited by having observations from only one university. Future studies will also benefit from the inclusion of data from more universities in more states that have and have not legalized marijuana.

We recognize that the biggest limitation of the analysis in this paper is the lack of an available control group with respect to the treatment of legalization. It is impossible at this stage to claim with certainty that the changes in marijuana use at WSU are caused by legalization rather than some other underlying changes. Nevertheless, we find evidence

that is consistent with the hypothesis that legalization is the cause of the changes in marijuana use among the students in our sample.

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Figure 1. Marijuana and other substance use trends: Probability of having used in the past 30 days (deviations from year 2012)

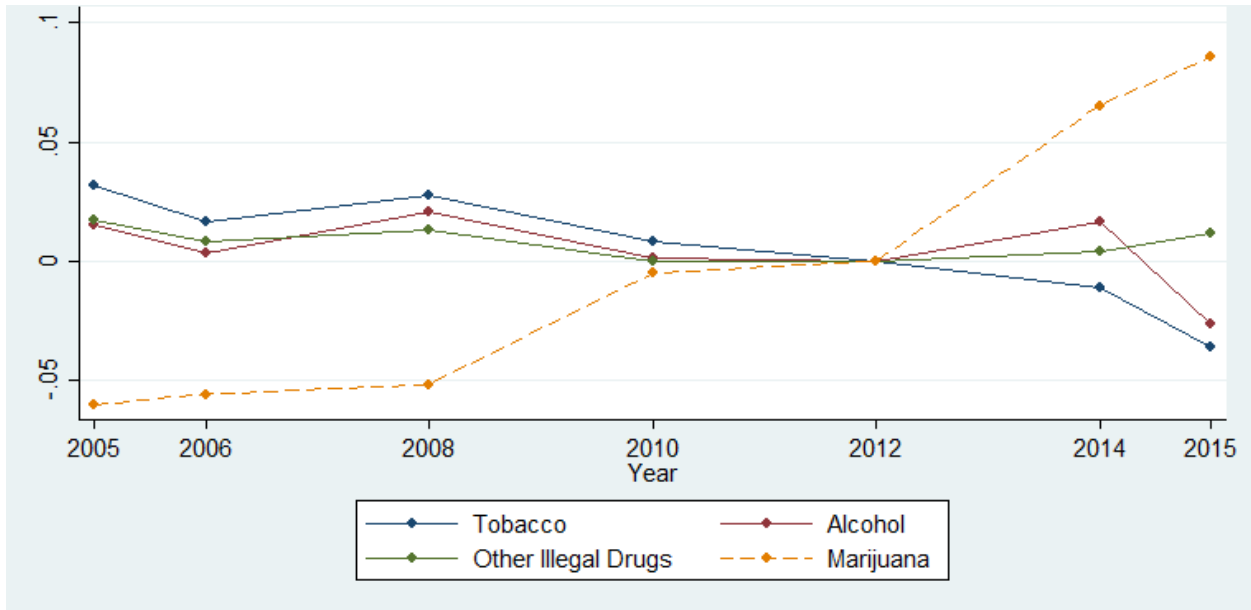


Table 1. Distribution of Students [across](#) Years in the WSU Sample of NCHA Data

Year	Number of Students
2005	988
2006	1,298
2008	1,737
2010	1,418
2012	3,253
2014	3,568
2015	2,223

Note: Mean number of students across all years is 2,069, with a standard deviation of 924.

Table 2. Summary Statistics for NCHA Variables Used

Variable	Mean	Standard Deviation	Pre-2014 Mean	2014-2015 Mean
Used Marijuana Past 30 Days	0.20	0.40	0.16	0.26
Number of Days Used Marijuana Past 30 Days	1.71	5.50	1.25	2.39
Age in Years	20.49	2.94	20.59	20.36
Legal Age (21 and older)	0.39	0.49	0.41	0.36
Male	0.42	0.49	0.43	0.40
Race†: White	0.80	0.40	0.82	0.78
Race†: Black	0.03	0.18	0.03	0.05
Race†: Asian	0.12	0.33	0.11	0.14
Race†: Hispanic	0.08	0.27	0.06	0.11
1st-year Undergraduate	0.31	0.46	0.29	0.34
2nd-year Undergraduate	0.22	0.41	0.22	0.22
3rd-year Undergraduate	0.24	0.43	0.25	0.24
4th-year Undergraduate	0.18	0.38	0.19	0.16
5th-year Undergraduate or More	0.05	0.22	0.06	0.05
International Student	0.06	0.23	0.06	0.06
GPA	3.07	0.71	3.10	3.04
Member of Fraternity/Sorority	0.17	0.38	0.15	0.21
Residence: Campus Residence Hall	0.40	0.49	0.39	0.42
Residence: Fraternity/Sorority House	0.07	0.26	0.08	0.06
Residence: Other University Housing‡	0.07	0.26	0.07	0.07
Residence: With Parents	0.01	0.10	0.01	0.01
Residence: Other Off-campus Housing	0.44	0.50	0.45	0.43
Used Tobacco Past 30 Days	0.19	0.39	0.20	0.17
Used Alcohol Past 30 Days	0.68	0.47	0.68	0.68
Used Other Illegal Drugs Past 30 Days	0.04	0.21	0.04	0.05

Number of Observations = 13,335

†Many students reported multiple races and are thus included in multiple race groups. Other races not reported include American Indian, Hawaiian/Alaskan Native, and all other races, and constitute about 5 percent of the sample.

‡Other on-campus housing includes graduate-student and family housing.

Table 3. Probability of Having Used Marijuana in the Past 30 days

VARIABLES	(1) logit I	(2) logit II	(3) logit III	(4) logit IV
Year 2014 (After Vote)	0.0345*** (0.0124)	0.0293** (0.0122)	0.0241** (0.0118)	0.0197** (0.00949)

Year 2015 (After Legal Sales)	0.0430*** (0.0154)	0.0418*** (0.0152)	0.0334** (0.0147)	0.0334*** (0.0124)
Year Trend	0.0118*** (0.00189)	0.0123*** (0.00186)	0.0115*** (0.00182)	0.0117*** (0.00145)
Male		0.0651*** (0.00724)	0.0600*** (0.00706)	0.0179*** (0.00581)
Race: White		0.0471*** (0.0114)	0.0408*** (0.0114)	0.000752 (0.00997)
Race: Black		0.0759*** (0.0235)	0.0622*** (0.0228)	0.0651*** (0.0205)
Race: Asian		-0.0446*** (0.0124)	-0.0298** (0.0126)	-0.0183* (0.0100)
Race: Hispanic		0.0279* (0.0159)	0.00920 (0.0151)	0.00925 (0.0120)
2nd-year Undergraduate		-0.000526 (0.0117)	-0.0523*** (0.0112)	-0.0299*** (0.00947)
3rd-year Undergraduate		-0.00392 (0.0143)	-0.0517*** (0.0138)	-0.0304*** (0.0117)
4th-year Undergraduate		0.0194 (0.0179)	-0.0363** (0.0163)	-0.0292** (0.0130)
5th-year Undergraduate or More		0.0118 (0.0243)	-0.0496*** (0.0187)	-0.0388*** (0.0140)
International Student			-0.0717*** (0.0130)	-0.0362*** (0.0108)
GPA: 2.0			0.0115 (0.0257)	0.0123 (0.0217)
GPA: 3.0			-0.0181 (0.0244)	0.0123 (0.0199)
GPA: 4.0			-0.0993*** (0.0200)	-0.0319* (0.0184)
Member of Fraternity/Sorority			0.122*** (0.0117)	0.0395*** (0.00853)
Residence: Fraternity/Sorority House			0.121*** (0.0200)	0.0413*** (0.0144)
Residence: Other University Housing			0.0877*** (0.0204)	0.0438*** (0.0161)
Residence: With Parents			0.0333 (0.0463)	0.0231 (0.0381)
Residence: Other Off-campus Housing			0.126*** (0.0115)	0.0571*** (0.00942)
Used Tobacco Past 30 Days				0.165*** (0.0107)
Used Alcohol Past 30 Days				0.210*** (0.00573)
Used Other Illegal Drugs Past 30 Days				0.432*** (0.0288)
Age Dummies	NO	YES	YES	YES
Pre-2014 Probability of Marijuana Use = 0.16				
Observations = 13,335				

Logit results reported as marginal effects.

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Omitted sex is female.

Omitted race is other races: including American Indian, Hawaiian/Alaskan Native, and all other races.

Omitted year in school is 1st-year undergraduate.

Omitted GPA is 1.0.

Omitted residence is university residence hall.

Table 4. Probability of Having Used Marijuana in the Past 30 Days- By Subgroup

		(1)	(2)	(3)	(4)
VARIABLES		Under 21	21 and over	Male	Female
(I)	Year 2014 (After Vote)	0.0435*** (0.0165)	0.00827 (0.0175)	0.0134 (0.0190)	0.0399** (0.0160)
	Year 2015 (After Legal Sales)	0.0467** (0.0200)	0.0382 (0.0234)	0.0280 (0.0241)	0.0492** (0.0197)
	Year Trend	0.0108*** (0.00249)	0.0146*** (0.00275)	0.0140*** (0.00289)	0.0116*** (0.00247)
	Pre-2014 Probability of Marijuana Use	0.18	0.15	0.20	0.14
Observations		8,152	5,183	5,552	7,783
VARIABLES		(5)	(6)	(7)	(8)
		Race: White	Race: Black	Race: Asian	Race: Hispanic
(II)	Year 2014 (After Vote)	0.0186 (0.0136)	0.158* (0.0851)	0.0178 (0.0297)	0.140*** (0.0541)
	Year 2015 (After Legal Sales)	0.0287* (0.0168)	0.156 (0.104)	0.0279 (0.0365)	0.156** (0.0706)
	Year Trend	0.0144*** (0.00209)	-0.00176 (0.0133)	0.00810* (0.00489)	-0.00158 (0.00887)
	Pre-2014 Probability of Marijuana Use	0.17	0.18	0.11	0.15
Observations		10,718	460	1,637	1,016
VARIABLES		(9)	(10)	(11)	(12)
		International	Domestic	Greek	Non-Greek
(III)	Year 2014 (After Vote)	0.0155 (0.0282)	0.0267** (0.0128)	0.0490 (0.0353)	0.0214* (0.0125)
	Year 2015 (After Legal Sales)	0.0578 (0.0524)	0.0359** (0.0157)	0.0548 (0.0414)	0.0267* (0.0156)
	Year Trend	0.00703 (0.00554)	0.0132*** (0.00195)	0.0201*** (0.00588)	0.00958*** (0.00187)

Pre-2014 Probability of Marijuana Use	0.08	0.17	0.27	0.15
Observations	700	12,567	2,329	11,006

Logit results reported as marginal effects.

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

All regressions include age dummies, sex dummies, race dummies, and year-in-school dummies where appropriate.

Table 5. Probability of Having Used Other Substances in the Past 30 Days

VARIABLES	(1) Marijuana	(2) Alcohol	(3) Tobacco	(4) Other Illegal
Year 2014 (After Vote)	0.0293** (0.0122)	0.0159 (0.0136)	-0.00893 (0.0108)	0.00817 (0.00648)
Year 2015 (After Legal Sales)	0.0418*** (0.0152)	-0.00821 (0.0166)	-0.0243* (0.0125)	0.0216** (0.00922)
Year Trend	0.0123*** (0.00186)	0.000426 (0.00204)	-0.00201 (0.00157)	-0.00183** (0.000831)
Male	0.0651*** (0.00724)	-0.00812 (0.00843)	0.167*** (0.00722)	0.0196*** (0.00367)
Race: White	0.0471*** (0.0114)	0.155*** (0.0156)	0.0394*** (0.0113)	0.0133*** (0.00512)
Race: Black	0.0759*** (0.0235)	0.00232 (0.0231)	-0.0107 (0.0207)	0.00940 (0.0118)
Race: Asian	-0.0446*** (0.0124)	-0.0722*** (0.0162)	-0.0132 (0.0131)	0.000285 (0.00684)
Race: Hispanic	0.0279* (0.0159)	0.0430*** (0.0164)	-0.0162 (0.0144)	0.00560 (0.00802)
2nd-year Undergraduate	-0.000526 (0.0117)	0.0299** (0.0132)	-0.00608 (0.0113)	-0.00710 (0.00529)
3rd-year Undergraduate	-0.00392 (0.0143)	0.0328* (0.0171)	-0.0139 (0.0138)	-0.00532 (0.00685)
4th-year Undergraduate	0.0194 (0.0179)	0.0821*** (0.0197)	0.0132 (0.0170)	0.00839 (0.00927)
5th-year Undergraduate or More	0.0118 (0.0243)	0.104*** (0.0228)	-0.0400** (0.0178)	0.0239 (0.0163)
Pre-2014 Probability	0.17	0.68	0.20	0.04
Observations	13,335	13,335	13,335	13,335

Logit results reported as marginal effects.

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

All regressions contain dummies for age.

Omitted race is other races: including American Indian, Hawaiian/Alaskan Native, and all other races.

Omitted year in school is 1st-year undergraduate.

Table 6. Number of Times Used Marijuana in Past 30 days

VARIABLES	(1) OLS I	(2) OLS II	(3) OLS III	(4) OLS IV
Year 2014 (After Vote)	0.545*** (0.169)	0.467*** (0.167)	0.415** (0.166)	0.397*** (0.153)
Year 2015 (After Legal Sales)	0.303 (0.198)	0.315 (0.197)	0.265 (0.197)	0.239 (0.181)
Year Trend	0.132*** (0.0198)	0.145*** (0.0198)	0.133*** (0.0197)	0.157*** (0.0185)
Male		1.207*** (0.105)	1.168*** (0.103)	0.636*** (0.0963)
Race: White		0.612*** (0.181)	0.632*** (0.183)	0.275 (0.175)
Race: Black		1.337*** (0.362)	1.176*** (0.364)	1.233*** (0.333)
Race: Asian		-0.373** (0.185)	-0.291 (0.186)	-0.237 (0.177)
Race: Hispanic		0.452* (0.236)	0.265 (0.236)	0.314 (0.222)
2nd-year Undergraduate		0.159 (0.163)	-0.354** (0.166)	-0.107 (0.152)
3rd-year Undergraduate		0.393* (0.210)	-0.108 (0.210)	0.111 (0.195)
4th-year Undergraduate		0.764*** (0.244)	0.215 (0.246)	0.240 (0.227)
5th-year Undergraduate or More		0.830** (0.328)	0.146 (0.330)	0.274 (0.300)
International Student			-0.189 (0.202)	0.0271 (0.182)
GPA: 2.0			0.380 (0.409)	0.486 (0.382)
GPA: 3.0			-0.300 (0.389)	0.191 (0.365)
GPA: 4.0			-1.173*** (0.389)	-0.270 (0.364)
Member of Fraternity/Sorority			1.080*** (0.182)	0.378** (0.168)
Residence: Fraternity/Sorority House			0.668*** (0.257)	0.0296 (0.236)
Residence: Other University Housing			0.771*** (0.189)	0.464*** (0.170)
Residence: With Parents			0.786* (0.475)	0.541 (0.430)
Residence: Other Off-campus Housing			1.317*** (0.125)	0.771*** (0.116)
Used Tobacco Past 30 Days				2.558***

Used Alcohol Past 30 Days				(0.173)
				1.212***
				(0.0754)
Used Other Illegal Drugs Past 30 Days				6.895***
				(0.450)

Age Dummies	NO	YES	YES	YES
Pre-2014 Average Days of Marijuana Use = 1.26				
Observations = 13,335				

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Omitted sex is female.

Omitted race is other races: including American Indian, Hawaiian/Alaskan Native, and all other races.

Omitted year in school is 1st-year undergraduate.

Omitted GPA is 1.0.

Omitted residence is university residence hall.